The Geological Development of the Thora District, northern Margin of the Nambucca Slate Belt, eastern New England Fold Belt

E. C. LEITCH and D. ASTHANA

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Early Permian strata of the Nambucca Slate Belt abut Late Carboniferous sedimentary rocks of the Coffs Harbour Block across the Euroka Fault north of Thora in northeastern New South Wales. Massive black siltstone and redeposited coarser clastic rocks of volcanic provenance, grouped in the *Moombil Siltstone*, characterize the Coffs Harbour Block. They dip steeply and young to the north. An imperfect slaty cleavage fabric formed during low-grade regional metamorphism is overprinted by a biotite-bearing static thermal metamorphic assemblage. The *Glenifer Adamellite* and members of the *Dundurrabin Granodiorite* were emplaced in the Coffs Harbour Block synchronous with the static metamorphism. The Nambucca Slate Belt sequence comprises two siltstone-dominated sedimentary units, the *Bellingen Slate* (>1000 m) and the *Buffers Creek Formation* (>1500 m) which are separated by pillowed and massive flows and shallow intrusives of the *McGraths Hump Metabasalt* (2000 m). Despite complexities at the top of the last unit the sequence is considered conformable. Sandstone and conglomerate within the Nambucca Slate Belt units are all redeposited; they are mainly of intermediate-silicic volcanic provenance and are associated with thin ash-fall tuffs. Deposition occurred within a narrow rift similar to those formed at the onset of ocean-basin evolution. However only local emplacement of ocean-ridge basalt took place. Microdiorite and later microadamellite, that collectively comprise the *Dorrigo Mountain Complex*, were emplaced in the Nambucca Slate Belt during or before deformation. Deformation and accompanying prehnite-pumpellyite metagreywacke facies regional metamorphism, at about 255 Ma, resulted from regional compression and a reversal of movement on faults that developed during rifting. The Coffs Harbour Block and the Nambucca Slate Belt were in close proximity at the time of emplacement of the Dundurrabin Granodiorite, for members of this unit are found south as well as north of the Euroka Fault but their earlier spatial relationship is not known. Late movement on the fault is indicated by contrasts in metamorphic character, and deformation features in adjacent granites.

E. C. Leitch and D. Asthana, Department of Geology and Geophysics, University of Sydney, Australia 2006; *manuscript received 12 December 1984, accepted for publication 17 April 1985.*

INTRODUCTION

The eastern part of the New England Fold Belt is made up of a mosaic of fault-bounded blocks each characterized by a distinctive geological history. Recent investigations (Flood and Fergusson, 1982; Cawood, 1982; Cawood and Leitch, 1985) indicate that the blocks developed during the Permian disruption of a formerly simple arrangement of tectonic elements by strike-slip faulting and major folding. Disruption was accompanied by rapid sedimentation, mafic and silicic magmatism, metamorphism and penetrative deformation.

In this paper we describe the geological development of the Thora district in the Mid-North Coast region of northeastern New South Wales (Fig. 1). It is geologically significant for several reasons: (i) it straddles the boundary between two of the major blocks, the Coffs Harbour Block and the Nambucca Slate Belt, (ii) rocks of the Nambucca Slate Belt here are less highly metamorphosed and less deformed than further south, they form a recognizable stratigraphic sequence, and primary structures are preserved, (iii) the sequence includes a thick unit of basaltic rocks, rocks only sparsely developed elsewhere in the Slate Belt, and (iv) structural and metamorphic relationships between stratified rocks and several small granitic bodies can be established.

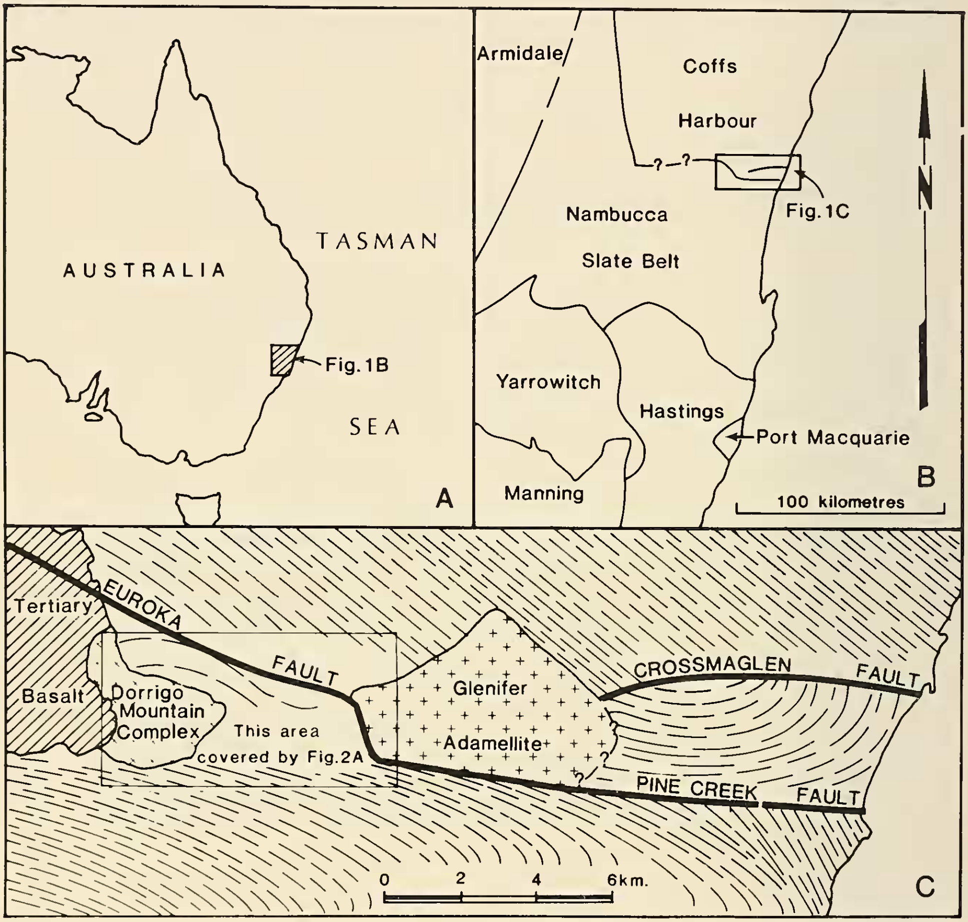


Fig. 1. Location and geological setting of Thora District. **A.** General location. **B.** Major structural blocks of the southeastern New England Fold Belt. **C.** Eastern part of Bellingen Fault System. Dashed lines indicate strike of slaty cleavage.

The Thora district is rugged, mostly heavily timbered and traversed by few roads or tracks. Impenetrable masses of lantana encroach on once-cleared areas and choke many of the smaller creeks. Most field work was carried out along the major drainage systems and the more openly forested ridges. Although outcrops on the latter are quite common most are loose and rubbly. Good outcrop occurs in the large creeks, notably the Little North Arm and Buffers Creek and their tributaries.

Grid references (g.r.) specified in this paper refer to the four 1:31 680 topographic sheets Bellingen (94537-II-S), Brooklana (9437-II-N), Darkwood (9437-III-S), and Dorrigo (9437-III-N), published by the New South Wales Department of Lands. A representative collection of rocks has been placed in the collection of the Department of Geology and Geophysics, University of Sydney (Catalogue numbers 57673-57676, 59637-59772).

PREVIOUS INVESTIGATIONS

Voisey (1934) distinguished between rocks south of the Bellingen River which he described as phyllite and slate and grouped in his Nambucca Series, and those further north, 'chert, quartzite and indurated slate . . . interstratified with phyllite' (p.335), which he termed the Coffs Harbour Series. He noted a major strike difference between the two units, and favoured an unconformable relationship, with the supposedly Silurian Coffs Harbour rocks overlying the Nambucca rocks of assumed Ordovician age. The same two divisions were recognized by Kenny (1936), who referred to the rocks in the north as the Fitzroy Series and placed the boundary between the units at Bonville Creek about 8 km north of the Bellingen River. Further work led Voisey (1959) to revise his earlier assumption in favour of a fault contact between the units, supposedly a left-lateral transcurrent structure he variously referred to as the Bellinger or Bellenger Fault.

The two-fold division was retained by Leitch *et al.* (1971) who showed that each could be subdivided, and termed their areas of outcrop the Coffs Harbour Block and the Nambucca Slate Belt. They considered all the rocks to be of Late Palaeozoic age. A faulted boundary was maintained in the position indicated by Kenny where a fracture termed the Crossmaglen Fault was mapped. A parallel fault further south along the line of Voisey's Bellinger Fault was also recognized but this was shown as lying entirely within the Nambucca rocks.

Korsch (1978a, 1978b, 1978c) described the stratigraphic subdivision, metamorphism and sedimentary petrography of the southern part of the Coffs Harbour Block, whereas Leitch (1976, 1978) has given brief accounts of the regional metamorphism and structural development of the Nambucca Slate Belt.

ROCK UNITS

MOOMBIL SILTSTONE

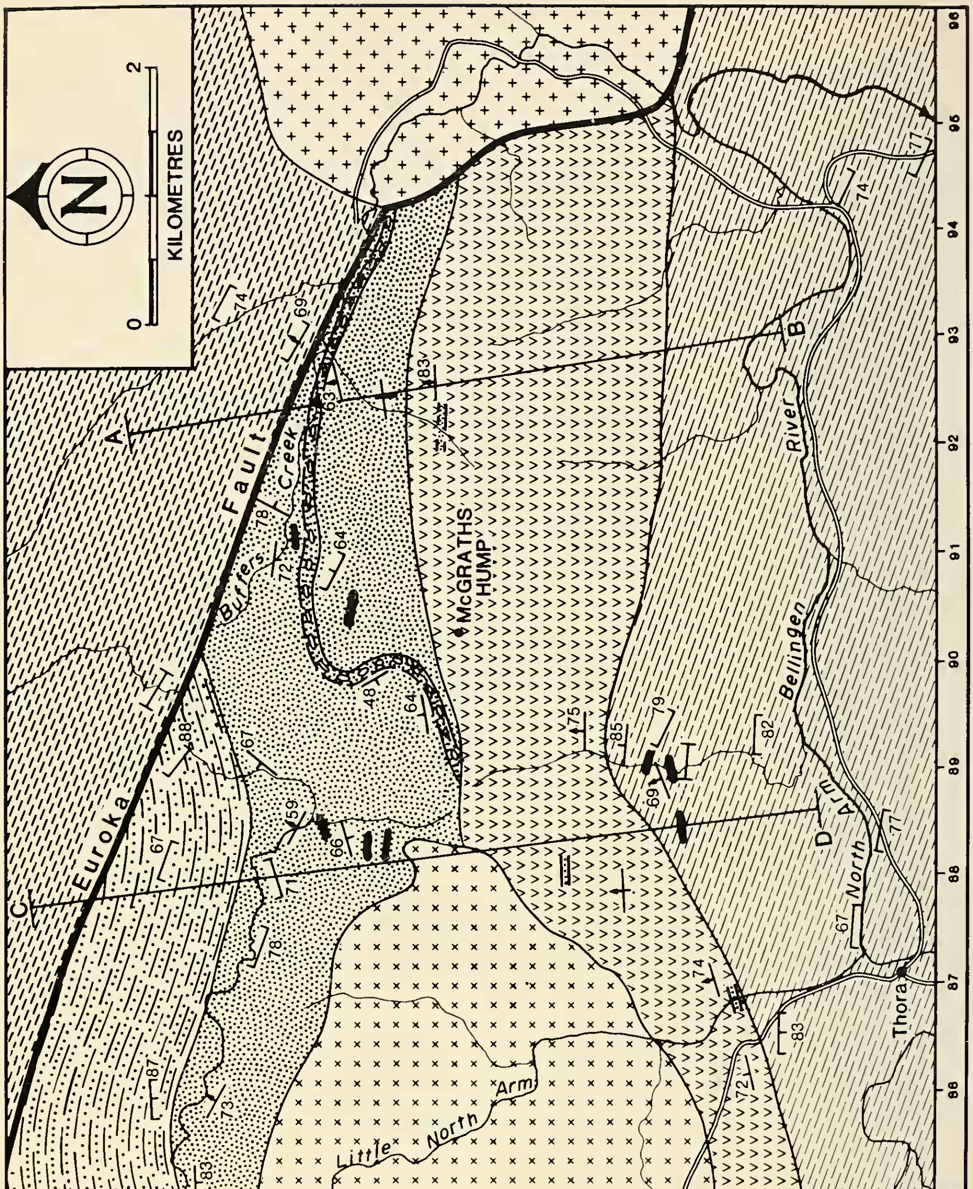
Nomenclature

Rocks north of the Euroka Fault (Fig. 2) comprise massive black siltstone and rare sandstone and granule conglomerate, imperfectly cleaved and largely lacking in sedimentary structures. They are typical of a widespread fine-grained unit that occupies the southwestern corner of the Coffs Harbour Block and have previously been grouped in the Moombil Beds (Leitch *et al.*, 1971; Korsch, 1978a). We suggest the name Moombil Siltstone is more appropriate for the unit, which derives its distinctive character both from its sedimentary parentage and the effects of biotite-grade static thermal metamorphism (Leitch, 1974; Korsch, 1978b). The name derives from Mt Moombil, 9 km northeast of McGraths Hump, where typical exposures of rocks occur.

Content

In the Thora district siltstone, by far the most abundant rock type, is characteristically fine-grained, dark, splintery and siliceous. Bedding is uncommon and other sedimentary structures have not been observed. A crude cleavage is widely developed. Thin section examination shows these rocks comprise a fine aggregate of anastomosing mica films, chlorite flakes and quartz, through which are scattered subangular quartz and plagioclase grains.

Sandstone forms massive grey beds 0.1 to 1.5 m thick some of which are graded. Angular intraformational siltstone clasts are locally prominent. Korsch (1978c) described the sedimentary petrography of these rocks and our observations confirm his main conclusions. The sandstones are lithofeldspathic rocks in which felsic volcanic fragments, some porphyritic in plagioclase, are most abundant (40%). Plagioclase and quartz are the most common detrital minerals each contributing about 15%. Quartz is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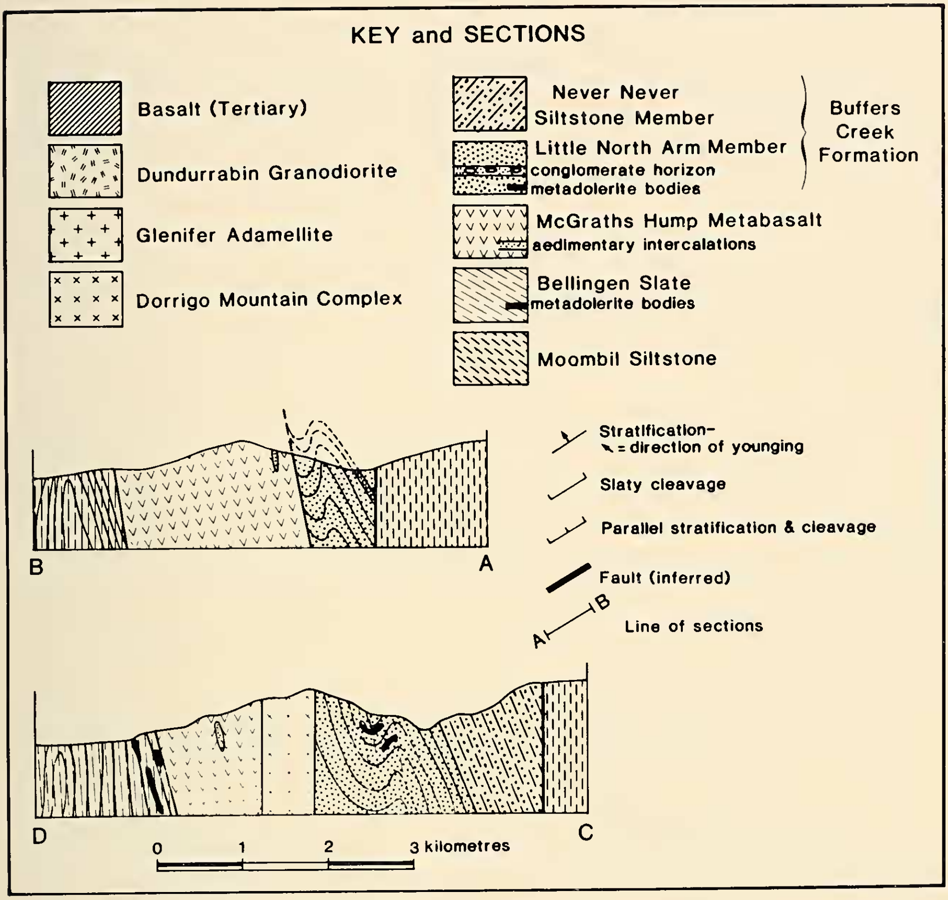

Fig. 2. Geological map and cross-sections, Thora district.

mostly of clear, monocrystalline, volcanic type. Both orthoclase and microcline are present, but together form no more than 1% of the rocks, and granitic fragments (quartz-perthite aggregates) and microlithic rock fragments are rare. The matrix, and possibly some detrital lithic grains, have been recrystallized to a fine quartz-mica-chlorite-albite aggregate.

Thickness and Age

Insufficient is known about the structure of the Moombil Siltstone to allow an accurate estimate of its thickness. Thus, although the unit outcrops over a wide area and consistently faces north, suggesting a considerable thickness (Korsch, 1978a), structural repetition cannot be ruled out (Fergusson, 1982). No fossils have been found in the Moombil Siltstone or in the adjacent Brooklana Formation (Korsch, 1978a). Detrital components are similar to those in Late Carboniferous rocks from elsewhere in the New England Fold Belt and this age appears most likely.

BELLINGEN SLATE

Definition

The name Bellingen Slate is applied to a sequence of cleaved siltstone containing interstratified micaceous sandstone and granule and pebble conglomerate that outcrops in the northern part of the Nambucca Slate Belt. The name is derived from the North Arm of the Bellingen River. Outcrops along the river between g.r. 713287 and 724297, some 14 km west of Thora, constitute the type section (Leitch, *in preparation*). Strata exposed in the south of the Thora district are lithologically indistinguishable from those in the type section and are included in this unit.

Distribution

Bellingen Slate outcrops over the southern quarter of the Thora district. In the north it is in contact with the McGraths Hump Metabasalt except in the extreme east where it abuts the Glenifer Adamellite.

Content

Soft, dark grey- to black-coloured slate, derived from the very low grade metamorphism of micaceous carbonaceous siltstone, is the most common and characteristic rock type in the Bellingen Slate. Beds range in thickness from 0.1 to 5 m with those thicker than about a metre showing internal stratification marked by changes in colour and grainsize. Reconstitution of these rocks is incomplete. Sand-sized grains of quartz and plagioclase are scattered through a groundmass of aligned turbid mica shreds, dark carbonaceous films, chlorite aggregates and quartz-albite lenses, the last probably remnants of silicic volcanic grains. Detrital mica flakes are widespread; many are squashed and kinked and they are distinguished from metamorphic mica on these characters and their relatively coarse grain size.

Pale grey and pale green siltstones interbedded with the slate are minor lithologies. They are harder than the latter, contain a greater proportion of groundmass quartz and are less well cleaved. Beds, some of which are laminated, rarely exceed 0.3 m in thickness.

Pale grey-coloured sandstone beds, many of which are graded, some from a basal division of granule conglomerate, occur throughout the Bellingen Slate. Beds range in thickness from 0.1 to about 2 m. In their upper parts some pass simply into siltstone whereas in others the graded layer is succeeded by rocks showing parallel and convolute layering and cross lamination (Bouma B and C divisions). The bases of sandstone beds are planar or are modified by loading.

Compositionally the sandstones are lithofeldspathic types in which grains of silicic volcanic rocks, siltstone of intraformational origin, clear volcanic quartz and plagioclase (now mostly altered to albite) are ubiquitous. Much of the lithic detritus has been affected by the low grade metamorphism of the rocks; grain boundaries are difficult to pick with the quartzo-feldspathic material of clastic fragments merging with similar material produced by recrystallization of the matrix. Irregular chlorite aggregates, probably highly altered mafic-intermediate volcanic clasts, are scattered through the rocks. Accessory detrital minerals are zircon, muscovite and biotite whereas the most common metamorphic phases are albite, quartz, white mica and chlorite. Calcite and prehnite are locally important secondary minerals.

Many of the sedimentary rocks of the Bellingen Slate are bioturbated and locally infaunal activity has destroyed sedimentary structures and modified rock textures.

The only igneous rocks in the Bellingen Slate are altered dolerite sills concentrated northeast of Thora, close to the southern contact of the McGraths Hump Metabasalt.

They range up to several tens of metres in thickness and contain screens of slaty rock. Some are incipiently cleaved.

Thickness and Age

Reversals in younging direction indicate that the Bellingen Slate is affected by macroscopic folds. Although exposure of the unit in the Thora district is too poor to allow axial traces to be accurately located, unrepeated sequences up to 1000 m thick are indicated from scattered younging determinations and persistent steep dips. Minimum thicknesses of 1300 m are indicated in the region around the type section where the structures can be better established.

No body fossils have been discovered in the Bellingen Slate. The unit is similar to thick micaceous siltstone sequences that were deposited widely over the southern part of the New England Fold Belt in the Early Permian. This age is consistent with metamorphism in the early Late Permian (c. 255 Ma; Leitch and McDougall, 1979) and with the inferred relationship of the formation to fossiliferous Early Permian rocks in the southern part of the Nambucca Slate Belt (Leitch, 1972).

McGRATHS HUMP METABASALT

Definition

The McGraths Hump Metabasalt comprises altered basaltic pillow lavas and massive flows, dolerite intrusions and rare intercalations of epiclastic sedimentary rocks, that outcrop to the north of the North Arm of the Bellingen River (Fig. 2). McGraths Hump, the prominent ridge between Buffers Creek and the North Arm, is the source of the name.

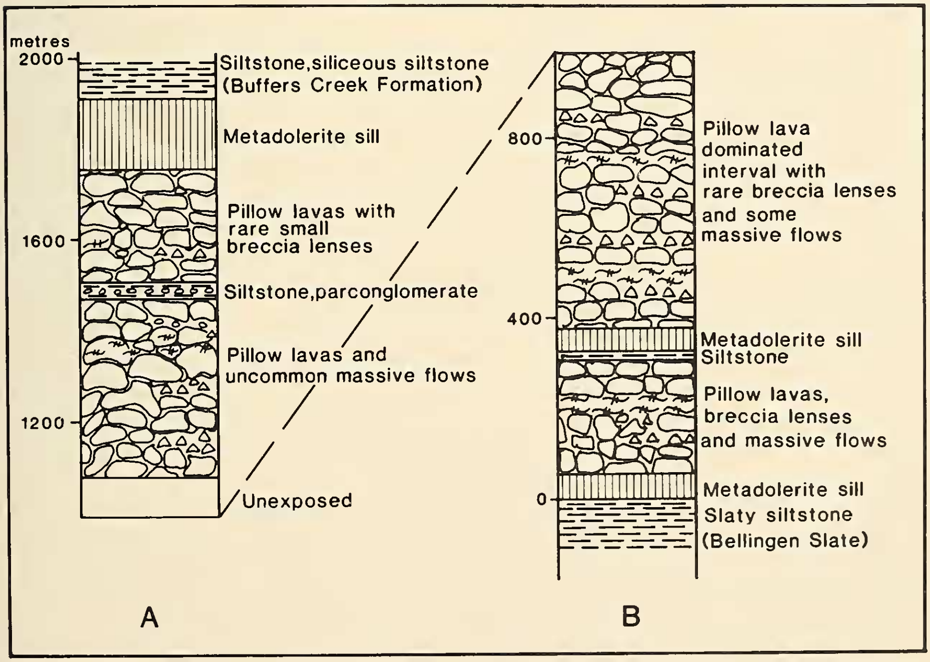

Fig. 3. Composite type section, McGraths Hump Metabasalt. Column **A** lies along a tributary of Buffers Creek (g.r. 922365-919357) whereas **B** is from the Little North Arm of the Bellingen River (g.r. 868332-865343).

A composite type section is designated (Fig. 3). That for the upper part of the formation lies along a tributary of Buffers Creek south from g.r. 922365 to the McGraths Hump ridge at g.r. 919357 whereas that for the lower part of the formation follows the Little North Arm north from g.r. 868332 to g.r. 865343. It is not possible to link these two sections by mapping but general structural trends suggest the top of the Little North Arm section lies less than 100 m stratigraphically below the lowest stratigraphic level reached in the Buffers Creek tributary section.

Distribution and Contacts

The McGraths Hump Metabasalt is faulted against the Glenifer Adamellite in the east and pinches out 3 km west of the area shown in Fig. 2, in steep, heavily-forested country north of Upper Thora. To the south the Metabasalt is considered to rest conformably on the Bellingen Slate. No exposure of the contact between the units has been located but the attitude of stratification in both is similar, both young north, the mapped position of the contact accords with a conformable relationship, and slaty sandstone intercalated in the lower part of the Metabasalt on the Little North Arm (g.r. 867335) is identical with sandstone in the Bellingen Slate. Altered dolerite bodies in the Bellingen Slate around g.r. 889342 are petrographically indistinguishable from those in the McGraths Hump Metabasalt and are possible representatives of the feeder system for this unit.

The nature of the boundary between the McGraths Hump Metabasalt and the Buffers Creek Formation to its north is incompletely established. The contact is exposed at the top of the type section (g.r. 922365) where a dolerite body is chilled against siltstone of the Buffers Creek Formation. Younging directions in the sedimentary rocks of the Buffers Creek Formation could not be determined here, but 250 m to the north graded bedding indicates south younging, whereas pillow structures in the McGraths Hump Metabasalt south of the dolerite show the latter unit youngs north. Either a small syncline occurs just north of the dolerite body or the contact is discordant. The latter interpretation is supported by the distribution of a conglomerate horizon within the Buffers Creek Formation which runs into the contact in the west (Fig. 2). On the other hand, the dolerite is geochemically allied with the other mafic rocks of McGraths Hump and the discordance must have formed before the end of mafic magmatic activity. One possibility is that deposition of the Buffers Creek Formation succeeded extrusion of McGraths Hump lavas with little or no break. Emplacement of a dolerite sill at the contact of the two units took place under a relatively thin cover of little-consolidated Buffers Creek strata and caused some disruption of these rocks, producing local overturning adjacent to the upper surface of the sill. Similar dolerite bodies occurring higher in the Buffers Creek Formation attest to the continuation of intrusive activity well after the commencement of deposition of this unit.

The contact between the McGraths Hump Metabasalt and the Dorrigo Mountain Complex is intrusive. A large mass of metabasalt that outcrops around g.r. 848338, surrounded by Dorrigo Mountain Complex rocks, is interpreted to be a large xenolith derived from the McGraths Hump Metabasalt that forms the wall-rocks nearby.

Lack of contact metamorphism and the presence of crushed granodiorite close to the contact indicate that the McGraths Hump Metabasalt is faulted against the Glenifer Granodiorite.

Content

Epiclastic metasedimentary rocks comprise less than 2% of the McGraths Hump Metabasalt, breccias less than 10%, dolerite intrusions no more than 15%, and massive and pillow basalt flows, with the latter of much greater abundance, the remainder.

Massive and pillowed flows. Basaltic rocks, characteristically fine-grained and of dark-green colour, form both pillow lavas and massive flows. Vesicles, always less than 4 mm diameter, are uncommon and larger irregular primary cavities, now filled by secondary minerals, are rare. The rocks are tectonically fractured but there is little sign of earlier cooling joints. Pillow structures are most readily identified in creek and cliff sections, but even where outcrops are too jointed and lichen-covered to allow recognition of individual sacs the presence of dark chilled selvedges suggests their presence. Pillows mostly have bean- or ellipse-shaped cross-sections, some with tear-drop shaped basal protruberances. The maximum dimension of pillows ranges from about 0.5 to 2.0 m; selvedges, now completely devitrified, are between 2 and 5 cm thick. Small pillows of near circular section occupy spaces between the larger sacs yielding a closely packed stack. Small inter-pillow interstices are filled by basaltic fragments and abundant secondary minerals.

Massive basaltic flows 1 to 5 m thick occur intercalated with the pillow lavas. Some show an incipiently brecciated base and a number have pillowed upper parts.

Breccias. Fragmental basaltic rocks are uncommon. They consist of angular clasts of devitrified selvedge and microcrystalline basalt cemented by a fine-grained aggregate of secondary minerals, mostly epidote, prehnite and albite. Blocks range up to about 10 cm in longest dimension and show no signs of rounding or sorting. Breccia mainly occurs in lenses less than 1 m in maximum thickness and in small inter-pillow spaces.

Metadolerite bodies. Most metadolerite bodies outcrop as scattered rounded boulders that are difficult to trace along strike and which do not show contacts with surrounding rocks. An intrusive habit and sill form are indicated in a few creek exposures where chilled margins up to 10 cm wide are present and contacts are approximately parallel to stratification as indicated by pillow shape. At least in the type section metadolerite bodies occur at the top and bottom of the McGraths Hump Metabasalt, with that at the base about 50 m thick and that at the top some 150 m thick and the thickest body recognized. Geochemical data (Asthana, 1984) indicate the metadolerite bodies are comagmatic with the flows and support the suggestion of Scheibner and Pearce (1978) that the rocks have ocean floor affinities.

Epiclastic sedimentary rocks. Sequences of epiclastic sedimentary rocks up to 30 m thick occur intercalated with the extrusive rocks. The most extensive consists of interbedded siltstone, siliceous siltstone and paraconglomerate found about 400 m below the top of the type section. These rocks are identical with those of the Buffers Creek Formation to the north. The siltstone comprises angular sand-sized grains of quartz and plagioclase scattered through a very fine-grained aggregate of turbid, low crystallinity mica, quartz, albite and chlorite. Siliceous siltstone is petrographically similar but with more quartz and less mica in the groundmass. Conglomerate contains abundant silicic volcanic pebbles, some porphyritic in plagioclase, some with a prominent vitroclastic texture, and others showing spherulitic recrystallization structures. Also present are clasts of sandstone, siltstone and basalt, the latter of intergranular texture in which fine plagioclase laths form a framework between which augite granules and small chlorite pools are preserved. The conglomerate matrix is a silty sand; grains of plagioclase, quartz and silicic lithic volcanics are the major components but it also contains rare detrital epidote, brown hornblende, and chlorite aggregates, all set in a turbid micaceous groundmass.

Siltstone in a unit 10 m thick found 300 m from the base of the formation (Fig. 3) is identical with that of the Bellingen Slate. Scattered angular grains of plagioclase and quartz, flattened silicic volcanic grains, and flakes of detrital biotite and muscovite, are set in a matrix composed mostly of aligned mica shreds which impart a cleavage to the rock.

Sandstone in irregular vein-like structures up to 3 cm wide occurs in massive lavas on the Dorrigo Mountain road at g.r. 864331. The sandstone consists of angular grains of plagioclase and silicic volcanic rock set a dark irresolvable matrix. The form of the bodies suggests they are small dykes emplaced in early joints in the metabasalt, their injection probably caused by the loading of a mobile sandstone bed by the basalt flow.

Thickness and Age

The composite type section, a near-complete section through the thickest part of the McGraths Hump Metabasalt, totals approximately 1900 m. To the west the top of the unit has been removed by emplacement of the Dorrigo Mountain Complex, and further west it progressively pinches out at the top of the Bellingen Slate. As both the Bellingen Slate and the Buffers Creek Formation are of Early Permian age the McGraths Hump Metabasalt which is intercalated between these two units is also accorded an Early Permian age.

BUFFERS CREEK FORMATION

Definition and Intraformational Stratigraphy

The Buffers Creek Formation is introduced here for the sequence of interbedded siltstone, sandstone, paraconglomerate and silicic tuff, together with associated dolerite bodies and possibly a lens of pillow basalt, that outcrops along the northern margin of the Nambucca Slate Belt in the Thora district. Buffers Creek, which cuts through the eastern part of the unit, is the source of the name.

The formation has been divided into two members. The stratigraphically lower is termed the Little North Arm Member, from the tributary of the Bellingen River of the same name. This member comprises interbedded grey, green and black siltstone and sandstone, conglomerate and silicic tuff. A prominent paraconglomerate horizon has been mapped in the lower part of the member and several outcrops of mafic igneous rocks occur in the unit. The lower part of the Little North Arm Member is typically exposed along Buffers Creek from g.r. 930370 northwest to g.r. 928372 and then southeast up a tributary stream to g.r. 922364, whereas the upper part of the member is typically exposed along the Little North Arm from g.r. 860383 to g.r. 872381. A thickness of about 800 m is indicated.

The Little North Arm Member passes gradationally up into a lithologically monotonous unit to which is applied the name Never Never Siltstone Member after the Never Never State Forest. This consists mostly of massive grey and green siltstone with widespread thin silicic tuff beds and only rare coarse epiclastic rocks. It is typically exposed along the Little North Arm of the Bellingen River and a prominent tributary between g.r. 850384 and g.r. 845387. The top of the member is cut off by the Euroka Fault and calculations based on numerous bedding orientations indicate a minimum thickness of about 1400 m.

Distribution and Contacts

The formation outcrops in an irregular, eastward tapering wedge from the Dorrigo Plateau 4 km southeast of Dorrigo to near the confluence of Buffers and Never Never Creeks. To the north it is faulted against the Moombil Formation along the Euroka

Fault, in the west and southwest it is cut off by the intrusive rocks of the Dorrigo Mountain Complex and to the east it is faulted against the Glenifer Granodiorite. In the south the Buffers Creek Formation adjoins the McGraths Hump Metabasalt.

Content

Siltstone, the major constituent of the Buffers Creek Formation, ranges from hard, conchoidally fracturing, pale grey and green siliceous varieties to softer, well-cleaved, dark grey to black types. The lighter-coloured rocks contain scattered small detrital relics of quartz and plagioclase (now albite) set in a groundmass composed of strongly aligned anastomosing shreds of white mica and smaller amounts of chlorite, albite and quartz. Albite and quartz form numerous narrow veins in these rocks and occupy small segregations elongate parallel to the mica fabric. Small grains and grain aggregates of pyrite and calcite occur in some samples.

The dark siltstones are less clearly recrystallized with much of the rocks consisting of murky, low-crystallinity mica interwoven with dark carbonaceous shreds and irregular chlorite patches. Some of these siltstones are uniformly fine-grained with tiny angular quartz and albite grains scattered through the phyllosilicate groundmass, whereas others contain scattered sand-sized grains of quartz, albitized plagioclase, and vitric silicic volcanic rock.

Siltstone beds range up to several metres in thickness although most thicker than a metre are internally thin-bedded or laminated. There are extensive siltstone-dominated sections in the formation wherein uncommon sandstone and tuff beds provide the only variation. Bioturbation of the siltstones is widespread. Some beds are crudely graded and irregular soft-sediment disruption has affected a few units.

Sandstone, grey in colour and mostly of fine to medium grainsize, is widespread in the Little North Arm Member. Individual beds range from a few centimetres up to at least 5 m in thickness. Graded beds are common as are beds with a prominent parallel lamination. Medium-sized cross-sets are discontinuously developed in the upper parts of some parallel laminated beds and small-scale cross-lamination (Bouma C division) is widespread in many thinner sandstones. Irregular syn-sedimentary deformation structures are widespread in the upper part of the Little North Arm Member. The bases of sandstone beds are sharp and usually planar or slightly loaded; scours and erosional sole markings have not been observed.

Petrographically the sandstones are feldspathic and lithofeldspathic varieties. Detrital quartz abundance ranges between about 10 and 20%. Most of the feldspar is albitized plagioclase but grains of orthoclase are also present. Lithic grains are mostly volcanic; vitric silicic types are most abundant and are accompanied by small amounts of microlitic and highly altered mafic volcanic detritus. A few granitic fragments, mainly coarse quartz-orthoclase intergrowths, occur in the sandstones, and flattened dark siltstone grains of intraformational origin are widespread. Detrital quartz is present in the form of clear, monocrystalline grains of volcanic provenance. Biotite flakes are a common minor detrital constituent; epidote, muscovite and zircon are present in small amounts.

Low grade metamorphism of these rocks is reflected in their finely granular quartz-albite-chlorite matrix that is flecked by small white mica flakes, and in the presence of replacement patches and veins of prehnite in several of the sandstones.

Hard, pale grey beds 0.02-0.3 m thick, interbedded with siltstone resemble chert but have a somewhat more granular appearance. Microscope and X-ray diffraction studies show they consist almost entirely of approximately equal amounts of quartz and albite that form an interlocking aggregate of fine anhedral grains. These rocks, described in detail by Leitch (1981), are considered to be recrystallized silicic ash-fall tuffs. Only rarely are traces of shard structure preserved but angular plagioclase crystals are widespread. Some of the beds are structureless, some graded and a few show cross-lamination.

Rudaceous rocks, with one exception, are restricted to the Little North Arm Member. Siltstone breccias, consisting of angular intraformational siltstone fragments up to 0.2 m long, set in a sandstone matrix, occur throughout this unit. Some form discrete beds ranging up to 2 m in thickness whereas others are the basal parts of beds that grade rapidly up into sandstone. Cobbles and pebbles of extrabasinal origin, together with abundant intraformational clasts, occur in a mappable conglomerate horizon several tens of metres thick in and south of Buffers Creek (Fig. 2). Intraformational debris comprises angular slabs, of massive and laminated siltstone and interbedded sandstone and siltstone up to 0.4 m in largest dimension. Extrabasinal material consists of clasts of silicic and intermediate volcanic rock, granodiorite, chert and vein quartz. The matrix is a sandstone of similar composition to the sandstone within the Buffers Creek Formation but much less well sorted and with a high silt content. Most of the conglomerate is of open framework character, with an average clast to matrix ratio of about 1:4. Conglomerate is lacking in internal structures; its lower contact is irregular and probably erosional but no upper contacts have been observed.

The only conglomeratic rock discovered in the Never Never Member is a thin ($<$0.1m) unit of paraconglomerate interbedded with siltstones near Cedar Falls at g.r. 890385. This rock consists of subangular pebbles of metabasalt set in a pale green, cleaved, siltstone matrix. The metabasalt pebbles show quench textures similar to those in some McGraths Hump Metabasalt rocks; subvariolitic plagioclase aggregates and elongate quenched augite prisms are set in a devitrified (chloritic) matrix.

No extrusive igneous rocks have been discovered in the Buffers Creek Formation but their presence is suspected. Between g.r. 884374 and 886376 blocks of basaltic pillow lava occur on the steep heavily timbered slope above Little North Arm Creek. The blocks, which are up to 10 m across, appear to be too large to have come from the small outcrops of McGraths Hump Metabasalt that just encroach onto the upper part of the slope, and a lens of metabasalt within the Buffers Creek Formation seems a more likely source. Although a search of the slope failed to reveal such a lens, several metadolerite masses were located, notably at g.r. 884373 where a 4 m wide dyke is emplaced in the formation, and at g.r. 882362 where several intrusions cut the unit. Metadolerite bodies were also noted in the Buffers Creek Formation further east (g.r. 903368 and g.r. 910373).

Age

Prismatic shell material in paraconglomerate of the Little North Arm Member at g.r. 893361 is believed to be fragments of the bivalve *Atomodesma* and hence to indicate a Permian age for the formation. Metamorphism of the rocks of the Nambucca Slate Belt in the early Late Permian (c. 255 Ma; Leitch and McDougall, 1979) provides an upper age limit for the unit.

DORRIGO MOUNTAIN COMPLEX

Nomenclature

The name Dorrigo Mountain Complex, first used by Leitch *et al.* (1971), is applied to a composite pluton of silicic and intermediate rocks that outcrops over an area of about 16 km^2 in and adjacent to the Dorrigo National Park. Typical exposures occur in extensive cuttings where the Dorrigo-Bellingen road ascends Dorrigo Mountain, the source of the name.

Content and Petrography

All outcrops of this pluton are sheared and many show brecciation, but in spite of much secondary alteration two distinct rock types are readily identified: an earlier microdiorite and a later microadamellite. The dioritic component has been extensively disrupted by intrusion of the microadamellite and in some exposures occurs as angular blocks ranging from 50 mm to several metres in longest dimension floating in the more silicic material. Elsewhere approximately planar dykes of microadamellite up to a metre wide transgress massive outcrops of microdiorite and in other outcrops the adamellite forms irregular anastomosing veins less than 0.3 m thick penetrating the dioritic rocks. Approximately equal amounts of the two rock types are present in the body.

The rocks show no obvious foliation and aplitic and pegmatitic veins are absent. No xenolithic material was found in the microdiorite, and blocks of the latter constitute the only xenoliths encountered in the microadamellite.

The microdiorite is an even-grained rock of hypidiomorphic-granular texture with an average grain size that rarely exceeds 1 mm. Plagioclase is the dominant phase; it is frequently extensively altered and partially replaced by albite. Magmatic relics are of andesine composition and show slight normal zoning. Potash feldspar is a minor constituent which occurs in small anhedral grains some of which are perthitic; cross-hatched twinning is absent. Small amounts of quartz are present, typically in strained, anhedral patches moulded around earlier phases. The major mafic mineral is colourless calcic clinopyroxene. No orthopyroxene was identified but chlorite aggregates which occur in all rocks have possibly replaced this phase. Green hornblende forms euhedral to subhedral crystals, some with a clinopyroxene core. Accessory minerals are apatite, an opaque oxide phase and zircon.

The microadamellite is of comparable grain-size to the microdiorite. It consists of approximately equal amounts of plagioclase, potash feldspar and quartz. Plagioclase is frequently altered; relics are very slightly zoned and have compositions close to the andesine-oligoclase boundary. Quartz, which is usually strained, forms anhedral masses which reach 2 mm in diameter. Subhedral potash feldspar shows microcline twinning in some grains but elsewhere in the same section only simple twins were observed. Chlorite has pseudomorphically replaced biotite. Accessory phases are hornblende, similar to that in the microdiorite, apatite, an opaque mineral, zircon and rarely allanite. Secondary minerals found in the complex are quartz, albite, chlorite, epidote, prehnite, sphene, calcite and pyrite.

Age

The pluton intruded the Buffers Creek Formation and the McGraths Hump Metabasalt prior to the end of deformation and regional metamorphism in the Nambucca Slate Belt. A late Early or early Late Permian age is thus indicated.

GLENIFER ADAMELLITE

Nomenclature

The name Glenifer Adamellite is applied to a granitic pluton that outcrops over an area of about 50 km^2 a few kilometres north of Bellingen. The body is typically exposed along the Never Never River between g.r. 002400 and g.r. 997385. Only its western part occurs in the Thora district (Fig. 2). Leitch *et al.* (1971) considered the pluton to be a composite body and termed its northern two-thirds the Glenifer Adamellite and the remainder the Valery Granodiorite. However modal analyses (Leitch, 1972) although showing that the rocks in the south have a higher plagioclase/microcline ratio than those further north, suggest a progressive rather than abrupt change in this ratio. No distinct contact between two discrete bodies can be recognized and we treat the pluton as a single mass.

Content and Petrography

The pluton is composed of slightly porphyritic medium to coarse-grained adamellite. Small xenoliths composed of a granoblastic aggregate of quartz, plagioclase and biotite are widespread. Aplite veins are rare and no pegmatitic material was noted. The rocks lack foliation but are cut by diversely oriented shears up to 20 mm wide along which severe cataclasis has taken place.

Typical adamellite consists of microcline phenocrysts set in a hypidiomorphic-granular aggregate of stout plagioclase laths, randomly oriented biotite flakes and rounded anhedra of quartz. Most microcline occurs in irregularly-bounded crystals up to 14 mm × 10 mm that poikilitically enclose grains of all other phases. Cross-hatched twinning is common in this mineral, although developed in widely differing degrees of perfection, and it is typically perthitic with exsolved albite occupying anastomosing microveins. Plagioclase laths average between 2 and 3 mm in length and are generally subhedral. They show only minor normal zoning and most are of oligoclase composition. Plagioclase enclosed within microcline is frequently embayed and shows irregular margins. Myrmekite occurs at boundaries between plagioclase and microcline in some rocks, commonly forming lobate projections into the alkali feldspar. Quartz is always anhedral and occurs in irregular masses up to 5 mm diameter. Subhedral plates of red-brown biotite up to 2.5 mm across tend to occur in clusters but show no preferred orientation. Opaque minerals, muscovite, apatite and zircon are accessory phases. Secondary alteration of the rocks is widespread. The most common products are quartz, albite and chlorite but epidote, prehnite, sphene and rutile have also been identified.

Although on an outcrop scale deformation appears to have been concentrated along discrete shears evidence of strain occurs on a microscopic scale in all rocks. Biotite flakes are bent and kinked, twin lamellae in plagioclase are distorted and, in the more markedly strained rocks, feldspar crystals have been fractured and displaced. Quartz has undulatory extinction and deformation bands are common, although in some rocks polygonization has produced strain-free aggregates of small crystals.

Age

The petrography of the Glenifer Adamellite indicates that it is a member of the Hillgrove Suite of the New England Batholith, a group of plutons typified by the presence of microcline rather than orthoclase, a quartz-rich character, the absence of hornblende and at least incipient cataclasis.

Flood and Shaw (1977) have shown that Rb-Sr whole rock isotopic data are consistent with an age of 289 ± 25 Ma for this suite (Shaw and Flood, 1981). An age within this range does not conflict with the geological relationships of the Glenifer Adamellite the only major constraints on which are that its emplacement post-dated deposition of the Moombil Siltstone and pre-dated the end of the faulting along the northern margin of the Nambucca Slate Belt. Hensel *et al.* (1982) reported a substantially older age for the Hillgrove Suite (312 ± 10 Ma) but the data on which this is based remain unpublished. This age, which seems to conflict with the emplacement of members of this Suite into strata of Early Permian age (Binns, 1966), may be that of an event other than the final intrusion of the bodies (Leitch, 1978).

DUNDURRABIN GRANODIORITE

Coarse, slightly strained biotite granodiorite has intruded the Dorrigo Mountain Complex and the Buffers Creek Formation in the northwest corner of the Thora district.

This mass, and similar rocks a little north of Dorrigo (Leitch *et al.*, 1971), are petrographically similar to the Dundurrabin Granodiorite and may be exposures of the eastern continuation of this body most of which is hidden by basalt. The Dundurrabin Granodiorite, a Hillgrove Suite body (Binns *et al.*, 1967) is probably of similar age to the Glenifer Adamellite although the possibility that members of the Suite collectively span a significant time range needs to be considered.

TERTIARY BASALT

Basalt flows and intervening fossil soil horizons and tuffs in the western part of the Thora district are part of the extensive basalt field that mantles much of the dissected plateau area west of Dorrigo. Basalt from Ebor, 30 km west of the occurrences mapped here, has yielded an Early Miocene K/Ar age (21 Ma; McDougall and Wilkinson, 1967).

METAMORPHISM

Mineral assemblages and textures in the Moombil Siltstone provide evidence for an early regional metamorphic episode (M1 of Korsch, 1978b) succeeded by a static thermal event (M2 of Korsch, 1978b). Thus in western outcrops an early slaty cleavage fabric is preserved in the alignment of relic detrital grains and the parallelism of micaceous films. However, the films now consist of tiny randomly oriented biotite flakes which have also grown in inter-film domains. The flakes become coarser in rocks further east but still retain a decussate form; scattered lithic fragments, detrital quartz and feldspar, and silt-sized material here is extensively recrystallized. Adjacent to the northwestern margin of the Glenifer Adamellite these rocks merge with completely recrystallized hornfels in which the typical assemblage is quartz-biotite-muscovite-plagioclase-(cordierite)-(garnet).

Subsequent to the growth of biotite and allied phases many of the Moombil rocks have been strained. Quartz shows strong undulatory extinction, biotite has been partially replaced by chlorite, and veins containing quartz, albite, chlorite, prehnite and calcite transect the rocks. The Glenifer Adamellite has been similarly affected.

All the Palaeozoic rocks south of the Euroka Fault have been affected by regional metamorphism under prehnite-pumpellyite metagreywacke facies conditions (Leitch, 1976). Phyllosilicate crystallization during metamorphism contributed to the development of slaty cleavage in the stratified rocks, but these conditions were also realized when small gashes and veins cross-cutting and disrupting cleavage were filled. The most diverse and characteristic prehnite-pumpellyite metagreywacke facies assemblages occur in the McGraths Hump mafic rocks. Non-specific quartz-albite-chlorite-white mica-(epidote)-(calcite) assemblages are widespread in the Buffers Creek Formation and the Bellingen Slate but both also contain quartz-prehnite bearing assemblages, as do rocks of the Dorrigo Mountain Complex. The more important assemblages in the stratified units are listed in Table 1.

Actinolite is patchily developed in McGraths Hump mafic rocks only within about 100 m of the southern contact of the Dorrigo Mountain Complex. It is believed to be of contact metamorphic origin, and is earlier than abundant quartz-prehnite-epidote-pumpellyite veins that cut these rocks. On the northeastern side of the Dorrigo Mountain Complex, dolerite within the Buffers Creek Formation contains actinolite of similar origin. Associated siltstone has recrystallized to hornfels containing a granoblastic assemblage of quartz, plagioclase, biotite and muscovite, throughout which are scattered small cordierite porphyroblasts. Replacement of cordierite by chlorite and white mica is widespread and the rock is cut by late chlorite-epidote veins.

TABLE 1

Regional metamorphic assemblages in stratified rocks of the Nambucca Slate Belt in the Thora district

Sandstone and siltstone (including slate)
Quartz — albite — prehnite — (calcite)
Quartz — albite — chlorite — prehnite — (calcite)
Quartz — albite — white mica — chlorite — prehnite — (calcite)
Quartz — albite — chlorite — epidote — prehnite — (calcite)
Quartz — albite — calcite
Quartz — albite — chlorite — (calcite)
Quartz — albite — white mica — chlorite — (calcite)
Quartz — albite — white mica — (calcite)

Silicic tuff
Quartz — albite — white mica
Quartz — albite — white mica — chlorite — (calcite)
Quartz — albite — white mica — epidote — (sphene)
Quartz — albite — epidote — prehnite — (calcite)

Metabasic rocks
Quartz — albite — chlorite — pumpellyite — prehnite — calcite
Quartz — albite — chlorite — pumpellyite — prehnite — (white mica)
Quartz — albite — chlorite — epidote — pumpellyite — prehnite — calcite
Quartz — albite — epidote — pumpellyite — prehnite
Quartz — albite — chlorite — epidote — pumpellyite — (white mica)
Albite — chlorite — epidote — calcite — white mica
Quartz — albite — chlorite — prehnite — calcite
Albite — chlorite — epidote — hydrogrossular
Quartz — albite — pumpellyite — prehnite — hydrogrossular — calcite — white mica

North of the Dorrigo Mountain Complex on the Little North Arm around g.r. 845387 siltstone of the Buffers Creek Formation has been converted to quartz-plagioclase-biotite-muscovite hornfels. In contrast to the cordierite-bearing rocks the stumpy mica flakes here show a strong preferred orientation, the result of mimetic crystallization parallel to earlier slaty cleavage. This thermal metamorphism is considered to result from the Dundurrabin Granodiorite, which is hence interpreted as having been emplaced after slaty cleavage formation. The character of the hornfels to the east tentatively suggests that the Dorrigo Mountain Complex was intruded prior to this event. The Dundurrabin hornfels is cut by quartz-prehnite veins and biotite is partially replaced by chlorite.

STRUCTURAL GEOLOGY

The Bellingen Fault System

Our detailed work in the Thora district, together with reconnaissance work to the east, indicates that the development of the boundary between the Coffs Harbour Block and the Nambucca Slate Belt resulted from movement along at least three sections of an east-west trending fault complex (Fig. 1**B**), which we refer to as the Bellingen Fault System (cf. Voisey, 1959). The fault section in the Thora district comprises the *Euroka Fault.* East of McGraths Hump it bends to the southsoutheast and joins the *Pine Creek Fault*, which transects Nambucca Slate Belt rocks near the coast but forms the southern boundary of the Glenifer Adamellite north of Bellingen (cf. Leitch *et al.*, 1971). The *Crossmaglen Fault* marks the southern boundary of the Coffs Harbour Block from the Bonville district (Kenny, 1936) west to the Glenifer Adamellite.

The Euroka and Crossmaglen Faults are marked by changes in rock type, metamorphic grade and, especially in the east, structural trend. The Pine Creek Fault marks a major change in the orientation of cleavage in Nambucca Slate Belt rocks, its presence indicated by large irregular conjugate kink folds, by sheared granite along the edge of the Glenifer Granodiorite, and by the absence of a contact aureole in the adjacent Bellingen Slate.

Complete specification of the movement history of the Euroka Fault must await mapping in the poorly exposed rocks east of the Glenifer Adamellite, as well as the results of investigations now underway west of Dorrigo. Early movements, mainly transcurrent, probably took place along the Euroka Fault — Crossmaglen Fault line. Emplacement of the Glenifer Adamellite disrupted this early structure and later faulting, with a large dip-slip component, was concentrated along the Euroka-Pine Creek line.

Structure North of the Euroka Fault

The only structural markers within the Moombil Siltstone, slaty cleavage and bedding, strike NW-SE and dip about the vertical (Fig. 4A). The few facing directions available indicate north-younging. Insufficient information is available to test the suggestion that these rocks have been disrupted by imbricate thrust faulting (Fergusson, 1982); the younging direction is consistent with this model but neither thrust surfaces nor repeated stratigraphic sequences have been recognized.

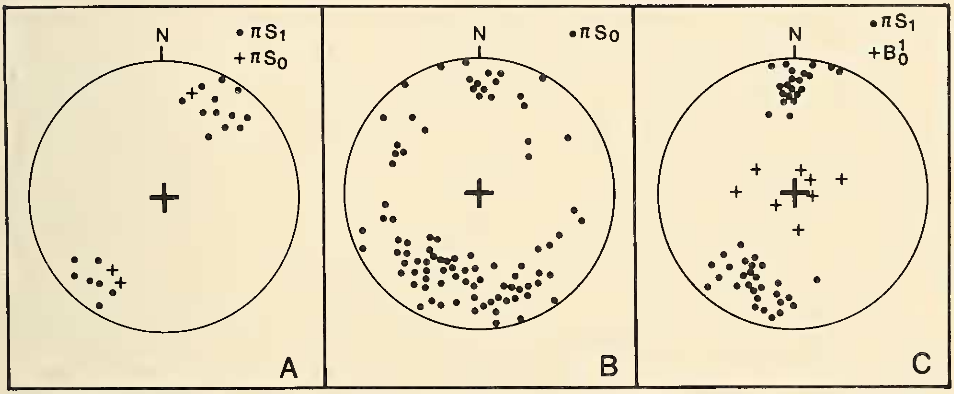

Fig. 4. Equal-angle stereographic projection of structural data. **A.** Poles to bedding (S_0) and slaty cleavage (S_1) from north of the Euroka Fault. **B.** Poles to stratification (S_0) from south of the Euroka Fault. **C.** Poles to slaty cleavage (S_1) and axes of mesoscopic folds with bedding as form surface and S_1 as axial surface structure (B_0^1).

Structure South of the Euroka Fault

Leitch (1978) showed that marginal parts of the Nambucca Slate Belt are characterized by the presence of an early slaty cleavage (S_1) that formed parallel to the axial surface of tight to isoclinal folds in bedding (S_0). Although later crenulation cleavages overprinted S_1 in central parts of the Belt the margins were only subsequently affected by a broad macroscopic warping unattended by the formation of penetrative mesoscopic structures. This general pattern holds in the Thora district. Here S_1, penetratively developed in metasedimentary rocks, is axial plane to tight-isoclinal mesoscopic folds in the Bellingen Slate (e.g. at g.r. 873323) and tight folds in the Buffers Creek Formation (e.g. at g.r. 868382). The folds have rounded profiles with narrow hinge zones and long limbs. The distribution of poles to S_0 (Fig. 4**B**), and the shape of mapped horizons within the Buffers Creek Formation, indicate that a comparable style prevails on a macroscopic scale. Overall S_1 strikes about NNW-SSE and dips steeply; poles to S_0 and the attitude of mesoscopic folds and lineations produced by the intersection of S_0 and S_1 indicate that major folds plunge steeply (Fig. 4**B**,**C**).

GEOLOGICAL HISTORY

Both the Coffs Harbout Block and the Nambucca Slate Belt provide important information on the Late Palaeozoic history of the eastern part of the New England Fold Belt, but their present juxtaposition is a result of movements on the Bellingen Fault System and evidence of their mutual relationships prior to emplacement of the Dundurrabin Granodiorite is lacking. Until detailed palinspastic reconstructions of the Late Palaeozoic arrangement of these structural blocks have been drawn up the depositional and early orogenic history of the rocks on either side of the Euroka Fault must be viewed independently.

Coffs Harbour Block: During Late Carboniferous times the Moombil Siltstone was deposited in an environment which received a steady influx of fine terrigenous sediment but into which sand-sized detritus was only infrequently carried by turbidity currents. An abundance of intermediate-silicic volcanic detritus in the coarser rocks indicates accumulation adjacent to a magmatic arc (Korsch, 1981), and tectonic reconstructions involving the rocks favour deposition in front of the arc (Flood and Fergusson, 1982). The dominance of fine-grained material is consistent with deposition in an outer fore-arc (including slope basin) or trench environment.

Deformation and accompanying regional metamorphism in the Late Carboniferous or Early Permian resulted in the near-vertical dip of the strata, the growth of white mica and other low-grade minerals and the imposition of a penetrative slaty cleavage.

Nambucca Slate Belt: The Nambucca Slate Belt sequence of the Thora district accumulated in a marine basin during the Early Permian. All coarse-grained sediment was carried in by mass flow and the resulting deposits are intercalated with more voluminous siltstones, some of which are probably turbidity current products and others the result of more continuous hemipelagic accumulation. There is no evidence of sediment reworking by bottom currents; thin tuff layers are preserved, and the emplacement of a mass of basalt up to 2000 m thick produced little change in the nature of sedimentation. These characters collectively indicate a deep-water environment.

One major episode of basaltic volcanism is indicated and perhaps a later, minor extrusion. The quiet effusion of mainly pillowed flows was the dominant eruptive process. Breccias probably formed at flow margins. There is no evidence for the contemporaneous sedimentary reworking of the basalts nor of interflow oxidation. Minor breaks in extrusion are indicated by thin intercalations of clastic sediments which also suggest that volcanism did not built up a significant topographic feature. Shallow intrusive activity accompanied volcanism.

Sedimentary detritus for the Slate Belt sequence was derived from a source dominated by silicic volcanic rocks, and the presence of ash-fall tuffs within the sequence indicates contemporaneous explosive activity. Some contribution from plutonic and low-grade metamorphic rocks is suggested by widespread detrital muscovite, orthoclase, microcline and zircon.

The tectonic character and position of the basin in which these rocks accumulated is difficult to discern. Sediment deposition on oceanic crust is implicit in the schemes of Leitch (1974, 1975, 1978), Scheibner (1973, 1976) and Cawood (1982). All favoured accumulation on the oceanic (eastern) side of a major mass of earlier subduction-accreted rocks. Leitch considered they were deposited in essentially the same basin as the earlier rocks whereas Scheibner and Cawood favoured deposition in a distinct marginal basin that opened in the Early Permian. The presence of basalts of mid-ocean ridge character intercalated with sedimentary material argues for accumulation in a basin undergoing active rifting, and the presence of interlayered sills, sedimentary rocks and silicic ash-fall tuffs, the volcanic provenance and the thickness of the sedimentary sequence, and the occurrence of alkalic rocks intercalated with the basin fill elsewhere (Asthana, 1984) are all consistent with a marginal basin origin (Dick *et al.*, 1980; Leitch, 1984). However, a recent reconstruction of the distribution of major crustal blocks in New England at the time of inception of the basin (Cawood and Leitch, 1985), indicates that rifting probably occurred within and to the west of the earlier accreted rocks. This basin was subsequently disrupted by major strike-slip faulting and large scale folding (Cawood, 1982; Flood and Fergusson, 1982; Asthana, 1984).

In spite of the occurrence of mid ocean-ridge type basalts in the Thora district there is no evidence to suggest that any organized pattern of spreading occurred within the basin. Basaltic rocks are rare overall, no truly pelagic rocks have accumulated, and all preserved parts of the basin received coarse epiclastic debris (Leitch, 1972). Although Cawood (1982) drew an analogy between the Nambucca basin and the Andaman Sea we consider that greater parallels lie with the earliest stages of opening of regions like the Gulf of Aden and the Gulf of California. In both these regions organized sea-floor spreading was preceded by normal faulting and diffuse spreading (Cochran, 1981; Moore and Curray, 1982). Moore and Curray recognized several types of extension in their study of the opening of the Gulf of California. The earliest stages involved (i) crustal thinning by normal listric faulting accompanied by variable amounts of dyke injection, and (ii) mixing of thinned fragments of continental crust with newly generated ocean crust. We doubt that rifting in the Nambucca Basin proceeded further than this (see also Scheibner and Pearce, 1978). Perhaps the Salton Trough at the head of the Gulf provides a useful tectonic analogue, with its history of rapid subsidence, thick sedimentation and inferred limited spreading (Crowell, 1981). The presence of both basaltic rocks of sea-floor type and rhyolites in this region (Robinson *et al.*, 1976) finds a parallel in the Nambucca Slate Belt where, in addition to the McGraths Hump Metabasalt silicic volcanic rocks occur locally (Leitch, 1982; McKelvey and Gutsche, 1969). It remains unclear as to whether basin opening was associated with large transcurrent movements as favoured by Cawood (1982) and is the case with the Salton Trough. In both rifting closely followed magmatic arc activity temporally, although in the case of southeastern California rifting occurred within the magmatic arc (Dickinson, 1981), whereas in New England it was concentrated in the fore-arc region.

In the Thora district emplacement of the Dorrigo Mountain Complex pre-dated deformation of the Nambucca Slate Belt rocks and intrusion of the Dundurrabin Granodiorite. Scheibner and Glen (1972) suggested the rocks were closely related to the McGraths Hump Metabasalt but preliminary geochemical studies (Leitch and Willis, *unpublished data*) indicate this to be unlikely. Rather, these rocks are regarded as early representatives of the New England Batholith *(sensu lato).*

Strong deformation of the Nambucca Slate Belt rocks followed emplacement of the Dorrigo Mountain Complex. Stresss was sufficiently high to produce slaty cleavage in sedimentary rocks but the more competent igneous material mostly remained massive and failed along discrete fractures. Slickensided, chlorite-covered surfaces produced during deformation are widespread in Dorrigo Mountain rocks, but less common in the McGraths Hump Metabasalt. Low grade regional metamorphism accompanied deformation; mineral assemblages indicate an intermediate pressure facies series with temperatures of about 300°C and pressures of approximately 4 Kbar (Leitch, 1976).

Several writers have suggested that deformation of the Nambucca Slate Belt occurred during subduction (Scheibner, 1973, 1976; Olgers *et al.*, 1974; Crook, 1980) but this view gains little support from our observations in the Thora district; we interpret the thick sequence here as a normal stratigraphic one not as a series of imbricate fault slices, the ocean-floor basalts probably do not have a faulted base, and melange zones are absent. The Nambucca basin probably closed by the reversal of movement on the normal faults active during basin development during regional compression. Basin fill was squeezed between the opposed margins. Steep fold plunges suggest lateral as well as vertical flow in reaction to compression and/or the presence of a significant shear component parallel to the basin margins during closure.

K-Ar dating of Nambucca Slate Belt rocks suggests deformation occurred at about 255 Ma (Leitch and McDougall, 1979), but data from the Coffs Harbour Block only constrain early deformation to an interval between the ages of the Moombil Siltstone (Late Carboniferous) and the Dundurrabin Granodiorite.

The Dundurrabin Granodiorite and the Glenifer Adamellite are probably of similar age, emplaced at the younger age limit of the Hillgrove Suite immediately after deformation of the Nambucca Slate Belt. Crustal thickening brought about by this deformation was probably important in triggering the melting of sedimentary material to yield the plutons (cf. Shaw and Flood, 1981). Recognition of Dundurrabin material on either side of the Euroka Fault suggests that the Coffs Harbour Block and the Nambucca Slate Belt were in close proximity by this time, although the faulted southern contact of the Glenifer body indicates later movements on the Bellingen Fault System. The gradational relationship between hornfels adjacent to the Glenifer Adamellite and the regional static metamorphic assemblage in the Coffs Harbour Block suggests that the static metamorphism accompanied emplacement of the Hillgrove Suite plutons. The presence of only a contact aureole around the Dundurrabin pluton in the Nambucca Slate Belt is considered to show that these rocks occupied a higher crustal position at the time of emplacement. Late movement on the Euroka Fault thus involved a large dip-slip component with downthrow to the south. Retrogression of the thermal metamorphic rocks, the formation of mesoscopic shear zones and deformation features including kink bands, undulose extinction and strain twins in the granitic rocks, and replacement of igneous phases by low-grade metamorphic minerals, are all related to late movements on the Bellingen Fault System.

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